

The Future of the Nuclear World

Introduction

Reducing the Nuclear Danger is the mission of Los Alamos National Laboratory (LANL). Additionally the Laboratory has initiated a project to examine a variety of nuclear related areas in the future some twenty to fifty years from now. The effort, known as the Nuclear Vision project, seeks to define a vision for the future which can simultaneously reduce nuclear dangers while allowing benefits from nuclear technologies to be realized. In creating such a vision, the effort examines pathways leading to them and seeks to identify steps that could begin in the near future to realize such visions. Of particular interest is identification of technologies and their possible impacts on important nuclear-related areas of the future. The scale of this effort is to address issues and circumstances of international, national, and local (Laboratory) impact and interest.

A guiding principle of our efforts is perhaps best expressed by University of California, Santa Cruz, Professor John Schaar: "The future is not a result of choices among alternative paths offered by the present, but a place that is created-created first in mind and will, created next in activity. The future is not some place we are going to, but one we are creating. The paths are not to be found, but made, and the activity of making them changes both the maker and the destination."

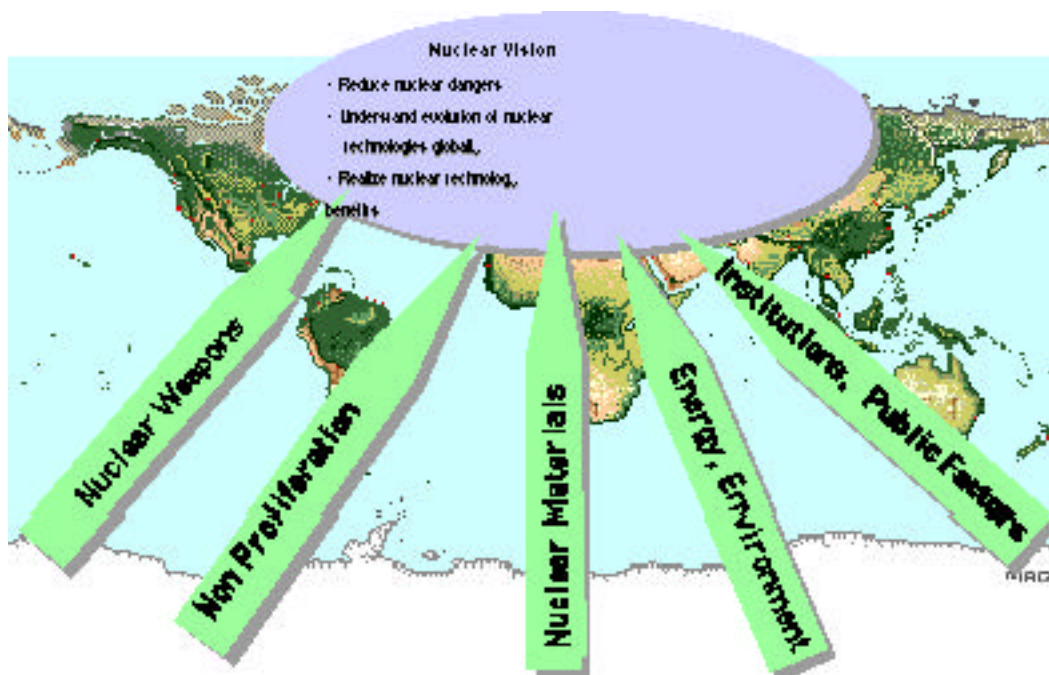
A little over 50 years ago, work at Los Alamos and elsewhere in the world set in motion developments in military and civil applications of nuclear science and technology. Over the years these ongoing developments have shaped history. The resulting "Nuclear Age" has had a significant impact on many aspects of society -- nationally and internationally.

Dramatic global political changes, including the end of the Cold War, have provided both opportunity and incentive for a thoughtful examination of the future of the global nuclear enterprise. The Global Nuclear Vision Project at Los Alamos National Laboratory is intended to explore how the evolution of "things nuclear" might progress over the next half century. These include the future of nuclear energy and other civil applications; nuclear weapons and proliferation; the institutions associated with, and public opinions about, nuclear science and technology; and environmental and other related issues.

The Nuclear Vision Project can be important to national, international, as well as Laboratory interests. The areas (listed above) that will be examined are a complex mixture of technology, institutional factors, and policy decisions. To provide mechanisms for obtaining knowledgeable information from a variety of sources, the Project will use a

series of workshops and research efforts, coupled with interactions with acknowledged centers of expertise.

Our attempts to create a "global vision" are, of course, motivated by the practical need to tie long-range objectives back to near-term actions and decisions through achievable steps and milestones. Any such global vision must seek a balance between minimizing the dangers and maximizing the benefits of the wide variety of nuclear technologies being pursued around the world. Pictorially this theme is shown below.



A second principle guiding our efforts is perhaps best expressed by University of California, Santa Cruz, Professor John Schaar: "The future is not a result of choices among alternative paths offered by the present, but a place that is created-created first in mind and will, created next in activity. The future is not some place we are going to, but one we are creating. The paths are not to be found, but made, and the activity of making them changes both the maker and the destination."

At the same time, we must consider these words in the context of certain realities that carry implications for the future: the increasing demand for nuclear energy in east Asia, the growing global inventories of nuclear materials, an increasing demand for energy coupled with the finiteness of many current fuel sources, the reduction of superpower stockpiles, the increasingly rapid diffusion of technical knowledge and capabilities across

the globe, and the risks of nuclear weapons proliferation and of proliferation of other weapons of mass destruction. Exactly where these current situations may lead is, of course, not known, but it is certain that the future will be shaped both by unanticipated events and intentional actions. Our task, then, is to think broadly about what is desirable and possible without abandoning the realm of possibility for that of fancy.

In this spirit, the Global Nuclear Vision Project does not attempt to predict the future but rather to explore alternative futures and their implications. In doing so, we hope to gain a deeper understanding that will guide our own actions as well as provide information relevant to current and future policy dialogues. We've chosen to address a nominal 50-year horizon, a realistic boundary given that technology development and implementation generally takes decades, the energy industry plans at least two or three decades ahead, and individual military systems, including ships, aircraft, and nuclear weapon, can remain in inventory for several decades.

Goals of the Project

Over 70 percent of Los Alamos National Laboratory's effort is associated with nuclear science and technology, including stewardship and support of the US nuclear weapons stockpile, nonproliferation activities, environmental technology, nuclear materials research, basic nuclear science, and energy technologies. No set of institutions span a broader scope of nuclear science, technology, and applications than do the suite of Department of Energy national laboratories. The Project's aim is to help build an improved understanding of the present role and potential future roles of nuclear science and technology, within Los Alamos, in other institutions, and in society. That understanding could help create a more coherent whole from interrelated, diverse applications of nuclear technology. The nation would also be strengthened by a better long-range view of the broad integration of nuclear science and technology and their applications.

Superb science is an essential ingredient in the execution of the Laboratory's core missions. Indeed, one role of a national laboratory is to aim applications of science beyond the natural time horizons that limit other types of institutions. The Global Nuclear Vision Project can help link today's science to potential future applications and issues and improve understanding of the technological/societal/geopolitical events that may drive the need for such science.

Elements of the Project

The Los Alamos Global Nuclear Vision Project consists of three elements-internal and external workshops, internal Los Alamos research and analysis projects, and efforts to

link work at the Laboratory with synergistic efforts throughout the United States and the world. Understanding and consensus on complex and interrelated global nuclear issues are the intended products of the project, and its success will be measured by how and whether the fruits of the Project impact actions and decisions. The media for this dialogue will be discussions in many forms -- published and informal.

The Workshops.

The Project began in August 1995 during a two-day workshop entitled, "Securing the Nuclear Future." Twenty-five members of the Los Alamos staff attended, and an equal number of experienced people from outside the Laboratory were invited, including participants from other nations. A second workshop, "Nonproliferation and International Security," was held in November 1995, and a third, "Nuclear Weapons and Stewardship Issues," in April 1996.

Planned events include a workshop on global nuclear energy and nuclear materials futures later this year. We plan to host at least one other workshop plus a final meeting to synthesize the work of previous workshops into a coherent vision statement. Important to our immediate plans will be a forum (tentatively set for late 1996 or early 1997) to discuss the Project and to receive public input.

Each workshop is designed to include the contributions of qualified experts who bring to the table a broad spectrum of perspectives and opinions ranging from general support of the benefits of nuclear technology to legitimate concerns about present and future nuclear activities.

Research and Analyses.

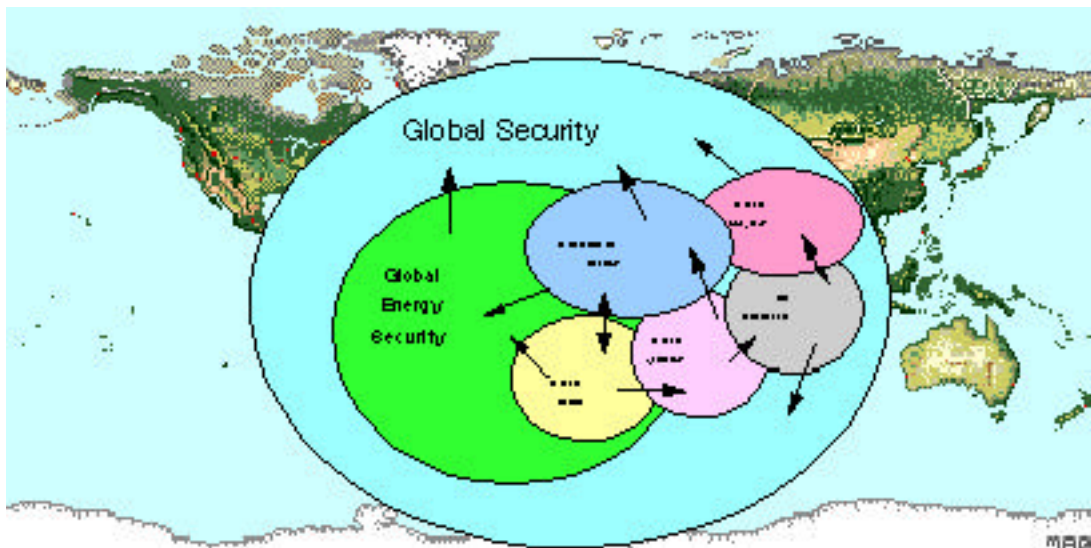
The second element of the Project, research and analyses, is supported using a small fraction of the Laboratory-directed Research and Development funds which are earmarked for long-range or forefront technology investigations. A few people supported by such funds are pursuing research and analysis on topics of direct importance to the Project. Examples include modeling of global energy needs, nuclear power scenarios, and resulting nuclear material inventories and flows; assessment of the impacts of nuclear technology developments on global nuclear materials inventories; exploration of the long-term implications of the global spread of technology, including nuclear power, for global nuclear weapon development capabilities; and identification of potential roles of nuclear weapons in future security environments.

Links to Related Efforts. A great deal of work relevant to the Nuclear Vision Project is being conducted outside the Laboratory, and we are fortunate in that we can build upon

the many established relationships. We are developing collaborations with appropriate individuals and groups throughout the US and internationally. In particular, we seek to broaden our relationships with the University of California through collaborative activities between the Laboratory and the Institute on Global Conflict and Cooperation (San Diego), the Center for Nuclear and Toxic Waste (Berkeley) as well as other UC sites and departments.

Pivotal Issues

Complex issues emerge almost immediately as one begins to think about global nuclear structures, the ways in which we might face the current and future nuclear realities of the world, and the best ways to minimize nuclear dangers while gaining benefits from nuclear technology. Identifying and understanding connections between the nuclear arena examined by this Project and other environments such as the ones shown here are key.



Although we are still in the early stages of the project, here are a few examples of the questions we have identified for further study.

What are salient features of future global nuclear weapons regimes (the context and defining features associated with nuclear weapon capabilities around the world)? How might future regimes evolve in the complex post Cold War international environment?

What are the linkages and tradeoffs associated with future global energy security -- including meeting energy and economic growth needs of developing nations -- and

nuclear power? How does the need to counter negative environmental factors such as increased carbon emissions from fossil fuels impact such relationships?

What is the nature of the relationship between the growing global inventory of nuclear materials and future dangers associated with proliferation of nuclear weapons? Will extensions of current safeguards for nuclear materials suffice? Could an inventory reduction strategy be applied? What technologies and institutional means would be attractive?

Could the spread of civilian nuclear technology create, over the long term, a condition of widespread "latent" nuclear weapon capabilities with attendant possibility of widespread proliferation races? What could be key triggers to such events? How could such situations be ameliorated?

What is the role of plutonium in future global nuclear energy scenarios? What technologies can prove effective in managing plutonium-both to utilize its energy content and minimize inventories that must be stored for eons?

Finally a key question most relevant for Los Alamos and other government institutions is what new science and technology should be explored to increase future options, especially in nuclear environments.

March 17, 1996 was the 50th anniversary of the Acheson-Lilienthal Report, which began efforts to place all applications of nuclear science and technology under international control. Such international control did not come to pass. During the ensuing 50 years, a fabric related to nuclear affairs, civil and military, has been woven from threads of bilateral, multilateral, and international arrangements. The implications for mankind of the potential-for good and ill-of the energy of the nucleus of the atom are still global, indeed more so today than in 1946. The fact that this potential will continue to be a major issue in world affairs is the driver for the Global Nuclear Vision Project.



Task Assignments for the Future of the Nuclear World

Task #1 – Current Nuclear Events

“The world that we have made as a result of the level of thinking that we have done so far, has created problems we cannot solve at the level of thinking at which we created them.”

- Albert Einstein

On March 17, 1946, the Acheson-Lilenthal Report was submitted to begin efforts to place all applications of nuclear science and technology under international control. Such international control has not come to pass. During the ensuing 50 years, a fabric related to nuclear affairs, civil and military, has been woven from thread of bilateral, multilateral, and international arrangements. The implication for mankind of the potential - for good and ill - of the energy of the nucleus of the atom are still global, indeed more so today than in 1946.

A little over 50 years ago, work at Los Alamos and elsewhere in the world set in motion developments in military and civil applications of nuclear science and technology. Over the years, these ongoing developments have shaped history. The resulting "nuclear age" has had a significant impact on many aspects of society - nationally and internationally.

To help us gain an understanding of the nuclear world and its future, we must begin to investigate current events and realities and how they affect our world today. You will investigate a variety of issues focusing on treaties, nuclear materials, nuclear weapons, and nuclear power and how the four domains (science, economics, politics, and social/cultural) impact decisions and behaviors.

As you begin to think about the future of the nuclear world, your task is to consider issues surrounding the current realities of the nuclear world. Within the framework established for this program, develop a multi-layered response discussing the varying perspectives in regard to the current realities and how they shape the world today.

The following Task is designed to help you synthesize historical material while considering current nuclear age realities. You are tasked to prepare a series of researched responses to the tasks listed below, within the context of the four domains (science, economics, politics, and social/cultural). The focus of these tasks is analyzing issues

surrounding the nuclear world. You are to research, gather data, and thoroughly demonstrate your understanding of the foundations of the current nuclear world.

1. Develop a multi-layered response discussing varying perspectives in regard to current realities and how they shape the world today. You may approach the task from one or more of the following specific areas:

- Issues dealing with negotiated treaties - compliance, non-compliance, etc.
- Issues dealing with disarmament - compliance, safety, storage, smuggling, etc.
- Issues dealing with disposition of excess nuclear materials – disposal sites, disposal methods, regulations, etc.
- Issues dealing with nuclear power - construction of nuclear power plants, regulations, nuclear fuel, etc.
- Issues dealing with environmental contamination and restoration



Suggested Classroom Activities for Task #1

- 1.** Conduct an international debate on the impact of living with the atomic bomb. Have students research varying nations and discuss the impact of the bombs existence within the four domains (science, economics, politics, social/cultural).
 - 2.** Have students find articles on current research being conducted at the national laboratories (these may be newspaper, magazine or Internet articles). Organize the articles by the scientific focus and create a list of the science concepts being studied. What impact does the research have on the local, regional and national communities.
 - 3.** Research the varying negotiated treaties dealing with the nuclear world. Look at how compliance, non-compliance, etc. is determine and dealt with.
 - 4.** Have student debate the unilateral disarmament issue. Have students develop varying scenarios of anti-nuclear activist practices in different countries within the context of the four domains (science, economics, politics, social/cultural).
 - 5.** Have students identify sources of nuclear materials. Dialogue issues dealing with disposition of excess nuclear materials within the context of the four domains (science, economics, politics, social/cultural). Research and discuss disposal sites, disposal methods, regulations, etc.
 - 6.** Have student look at issues dealing with nuclear power within the context of the four domains (science, economics, politics, social/cultural). Research and discuss construction of nuclear power plants, regulations, nuclear fuel, etc.
 - 7.** Have students research issues dealing with environmental contamination and restoration.
 - 8.** Invite guest speakers to discuss the impact of the nuclear world on their "personal work world" (business, educators, scientists, farmers, news media, etc.). Discuss spin-off products, national and international relations, security issues, the end of the "Cold War Era", etc. Have students prepare questions prior to the visit and have them keep records from the conversations.
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Task #2 – Future World Environments in General

"The future is not a result of choices among alternative paths offered by the present, but a place that is created - created first in mind and will, created next in activity.

The future is not some place we are going to, but one we are creating. The paths are not to be found, but made, and the activity of making them changes both the maker and the destination."

- Professor John Schaar (University of California, Santa Cruz)

The following task assignment is designed to allow you to speculate about what the world might look like 20 to 50 years from now. You are expected to approach the assigned tasks from different geopolitical perspectives and to develop responses to the tasks that reflects interaction between these different perspectives.

The Global Nuclear Vision Project does not attempt to predict the future but rather to explore broadly alternative possible futures and their implications. In doing so, we hope to gain a deeper understanding that will guide our own actions as well as provide information relevant to current and future policy dialogues. We've chosen to address a nominal 50-year horizon, a realistic boundary given that technology development and implementation generally takes decades, the energy industry plans at least two or three decades ahead, and the individual military systems, including ships, aircraft, and now nuclear weapons systems, can remain in inventory for several decades as well.

As we ponder the future, we realize that our present and future endeavors are built upon the experiences of the past. As we begin to speculate about the future, we need to step back for a moment and reflect on the changes that have occurred during the past centuries, especially the last 50-100 years. As A.S. Eddington stated,

"...our eyes once opened,... we can never go back to the old outlook....But in each revolution of scientific thought new words are set to the old music, and that which has gone before is not destroyed but refocused."

To help us gain an understanding of the nuclear world and its future, we will begin to investigate the nuclear world in general. You will investigate a variety of issues focusing on treaties, nuclear materials, nuclear weapons, nuclear power, and nuclear medicine and how the four domains (science, economics, politics, and social/cultural) impact the acceptance or rejection of nuclear processes.

Your task assignment is to speculate about what the nuclear world might look like 20 to 50 years from now. You are expected to approach the assigned task from different geopolitical perspectives and to come up with responses that reflect interaction between these different perspectives. You are to explore broadly alternative possible futures and their implications.

As you work on this task, keep the following in mind.

1. What is the "big picture"? What are the boundaries for the task?
2. Focus in on the "big picture". What are the parts/components necessary for completing the task? How are these parts/components related? Assign values/criteria to each part/component to determine priority levels.
3. What action can you take? How are you going to explain your position/decision?
4. Refer to the handouts on critical thinking, intellectual standards, and Socratic teaching.

The following Task is designed to help you synthesize research material while considering future nuclear world scenarios. You are tasked to prepare a series of researched responses to the tasks listed below, within the context of the four domains (science, economics, politics, and social/cultural). The focus of these tasks is analyzing issues surrounding the future of the nuclear world. You are to research, gather data, and thoroughly demonstrate your understanding of the foundations of the current nuclear world and how they might play out in the future.

In developing a vision for the future, we need to consider the past and current realities of the world in general. Within the framework established for the program,

1. Develop a multi-layered response discussing your vision in regard to the possible future realities and how they may shape future policy decisions.
 2. Develop several scenarios that could globally or regionally describe world environments and justify each of your developed scenarios. (You may want to consult with community members to get a well-rounded perspective on critical issues that shaped previous global change. You should consider the following areas:
 - Personal beliefs as to what the world might look like in 20-50 years and why
 - The nature of relations among nations and the role of the US in such a world
 - Views on Asian, European and Middle Eastern scenarios and their impacts on world futures
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Suggested Classroom Activities for Task #2

- 1.** Have students investigate and compare countries that have nuclear capability (power plants, weapons, medicine, technology) with those that do not have nuclear capability within the context of the four domains (science, economics, politics, social/cultural). Discuss the advantages or disadvantages of being a nuclear capable country.
 - 2.** Have students investigate the legacies of the "Cold War" as it pertains to nuclear capability. Where and what are the "Hot Spots"? What effect (positive or negative) has the development of a nuclear capacity (power, weapons, medicine, technology) had on human, animal and plant life?
 - 3.** Have students investigate the advances within the scientific domain within the last 100 years. How are these advances being used today? In what direction are these studies leading?
 - 4.** Discuss how scientific advances of the last century have helped or hurt world economies.
 - 5.** Discuss the role of different countries in world government before and after the development of the nuclear bomb. How does the shift of power correlate with the advances in nuclear physics? Discuss the roles of the haves and have nots (nuclear capability) in the realm of world government and decisions that affect all countries.
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Task #3 – Future World Environments, specifically energy

"For decades it has been clear to the scientific community that nuclear energy is destined to play an ever-increasing role for the generation of electricity throughout the world. Yet here in America, the birthplace of commercial nuclear energy, the promise and production of this technology has been brought to a near halt. Why?"

From the Foreword to "America the Powerless"
Dr. Glenn T. Seaborg (Nobel Laureate, 1951)

This task is designed to allow you to continue speculating about what the nuclear world environments might look like 20 to 50 years from now, specifically in the area of energy.

The energy sources that have fueled our industrial growth over the past two centuries are under attack for environmental concerns. Research has investigated a number of new approaches that may be able to replace our dependence on the fossil fuels we now use. Approaches being considered and areas in which research is being conducted include nuclear (fusion and fission), solar, wind, and hydrogen fuel cells. Each have their pros and cons.

As we ponder future energy needs, we realize that our present and future endeavors are built upon the experiences of the past. We recognize that the world's future energy use is all encompassing and that we need to approach energy use issues in more manageable areas of research. This task specifically focuses our efforts of the world developed in Task #2 onto the general areas associated with energy needs for economic development, environmental issues, the role of science and technology. You will address the energy issues in regard to their part in future decision making throughout the world.

Your task assignment is to speculate about the energy needs of the nuclear world 20 to 50 years from now. You are expected to approach the assigned task from different geopolitical perspectives, to collect appropriate data and come up with responses that reflect interaction between these different perspectives. You are to explore broadly alternative possible futures and their implications.

You must prepare a series of researched responses to the tasks listed below, within the context of the four domains (science, economics, politics, and social/cultural). The focus of these tasks is comparing different sources of energy and production methods.

In developing an understanding of the energy needs of human societies, we must look at the past, present, and projected future as we begin to narrow our research efforts toward specific areas of concern.

1. Develop a team vision in regard to the possible future world environments focusing specifically on energy issues and how they may shape future policy decisions.

Develop several scenarios that could globally or regionally describe world environments and justify each of your developed scenarios. You may want to consult with community members to get a well-rounded perspective on critical issues that shaped previous global change. You should include the following areas:

- Situations regarding future energy needs, particularly those occurring in rapidly developing nations
- Issues of the environment (i.e. global climate change, acid rain, etc.) along with steps to mitigate these problems
- Include ideas on areas where technology can have important impacts in the areas listed above or in other areas that will be key components of life in the future.



Suggested Classroom Activities for Task #3

- 1.** Have the students conduct research on energy for different types of human endeavor (production of food, production of heat and electricity, mining and processing raw materials, etc.)
 - 2.** Discuss whether a mix of sources and systems needed to meet future world energy needs will (could) exist at sufficient levels.
 - 3.** Examine the possibilities for movement from dependence on fossil fuels to other sources such as renewables (i.e., solar, wind, biomass, and nuclear power). Have students report out on the pros and cons of each type of fossil fuel energy source (renewable and nonrenewable).
 - 4.** Examine the roles of innovative technologies in energy production (i.e., improved photovoltaics, new nuclear technology, etc.) Have students discuss the viability of each technology and whether current human endeavors would finance such technology.
 - 5.** Examine the role of technology in energy use (i.e., electric cars, hydrogen as a fuel, etc.) Have students break into teams, each team taking an opposing view, and hold an academic dialogue on each technology with each team justifying their viewpoint.
 - 6.** Examine the issues in different geopolitical areas of the world where nuclear power currently plays or might play an important role in meeting their future energy needs. Discuss how the general population acts/reacts to the introduction of nuclear technology. Consider emotions, facts, energy needs, the environment, economics, etc.
 - 7.** Have students examine and discuss issues associated with future applications of nuclear power (i.e., safety, proliferation, pollution, waste management, etc.) Hold a debate where one side makes judgements based on emotion and the other on facts.
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Task #4 – Role of Things Nuclear in Future World Environments, specifically weapons

"Should a President, in the event of a nuclear attack, be left with the single option of ordering the mass destruction of civilians, in the face of the certainty that it would be followed by the mass slaughter of Americans? Should the concept assured destruction be narrowly defined and should it be the only measure of our ability to deter the variety of threats we may face?"

- President Richard M. Nixon, 1972

The development of the atomic bomb and the subsequent development of the hydrogen bomb and numerous design refinements over the past 50+ years has been a highly debated issue throughout the world. A nuclear arms race developed between the former USSR and the United States. Vast amounts of capital were expended and a huge industrial complex was created during this time. The world was under the veil of a "Cold War" with each side trying to keep the other from having a perceived military advantage over the other. The world was able to go through 50 years of relative "peace" with "minor regional" skirmishes between nations, but no "World War III". Detente was the buzzword for the time period. The question remains and is still being debated. Do nuclear weapons prevent war? This task specifically focuses the pictures of the world developed in Task #2 onto general areas associated with the role of nuclear weapons on future world environments. You will address issues in regard to how nuclear weapons will impact future decision making throughout the world.

Your task assignment is to speculate about the impact nuclear weapons will have on the decision making process in the nuclear world 20 to 50 years from now. You are expected to approach the assigned task from different geopolitical perspectives, to collect appropriate data and come up with responses that reflect interaction between these different perspectives. You are to explore broadly alternative possible futures and their implications.

You must prepare a series of researched responses to the tasks listed below, within the context of the four domains (science, economics, politics, and social/cultural). The focus of these tasks is comparing different sources of energy and production methods.

In developing an understanding and a vision for the future of arsenals that include nuclear weapons, we must look at the past, current realities, and projected future as we begin to narrow our research efforts toward specific areas of concern.

1. Develop and discuss a vision in regard to the possible future world environments focusing specifically on the role of nuclear weapons and how they may shape future policy decisions.
 2. Develop several scenarios that could globally or regionally describe world environments and justify each of your developed scenarios. You may want to consult with community members to get a well-rounded perspective on critical issues that shaped previous global change. You should consider the following areas:
 - Whether ways will (could) exist to control armed conflict in future global or regional societies, such as a move toward a world government, a resurgence of nationalism, and the importance of ethnic and historical factors governing such issues.
 - Examine the areas of nuclear weapons with emphasis on trends in nuclear weapons arsenals in the future, looking at START II, in terms of numbers, rapid disarmament, regrowth in numbers of weapons
 - Examine the areas of nuclear weapons with emphasis on trends in the number of nations having nuclear weapons beyond the U.S., (China, Russia, Great Britain, France, India, Pakistan) plus the undeclared weapon states (Israel)
 - Examine the areas of nuclear weapons with emphasis on roles for nuclear weapons, deterrence to other nuclear weapons, national prestige, deterrence to chemical and biological weapons use.
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Suggested Classroom Activities for Task #4

- 1.** Have the students identify national security issues for the United States. Make sure they consider issues in the context of the four domains (science, economics, politics, social/cultural).
- 2.** Have students consider national security issues from the perspective of different countries again within the context of the four domains.
- 3.** Hold a "United Nations" debate where students assume roles of delegates from different countries and defend their countries national security positions.
- 4.** Examine the roles of nuclear weapons spinoff technologies in business and medicine. Have student s discuss the viability of each technology and whether current human endeavors would finance such technology for a safer future.
- 5.** Examine the role of diplomacy in maintaining a nuclear arsenal. Have students break into teams, each team taking an opposing view, and hold an academic dialogue with each team justifying their viewpoint.
- 6.** Examine the issues in different geopolitical areas of the world where nuclear arsenals currently plays or might play an important role in the decision making process. Discuss how the general population acts/reacts to a countries nuclear capability. Consider emotions, facts, energy needs, the environment, economics, etc. nuclear weapons development (i.e., safety, proliferation, pollution, waste management, etc.) Hold a debate where one side makes judgements based on emotion and the other on facts.



Task #5 – Role of Nuclear Things in Future World Environments, specifically medical, industrial, and other applications

"Working with plutonium and other radioactive materials while limiting radiation exposures remains at the heart of our mission just as it was during the Manhattan Project. Concurrently, maintaining public trust regarding environmental, health and safety issues has become ever more important to the success of our mission."

- Dr. Siegfried S. Hecker, 1995

Former Director, Los Alamos National Laboratory

It has been conjectured by some that, because biological organisms evolved in the presence of low levels of ionizing radiation, we and other life forms must have developed effective mechanisms to repair the damage caused by this exposure. Others contend that even the lowest levels of radiation have the potential to cause serious biological effects, such as cancer or genetic disease.

In fact, no one knows for sure if low doses of ionizing radiation can produce serious biological effects on humans. What we do know is that high doses of radiation can produce such effects, and the risks can be quantified. From these known risks at high doses, one may estimate the risks associated with low doses, based on some procedure of extrapolation. Disagreement about such a procedure for extrapolating from high doses to the low doses that are of practical concern to radiation workers and the general public lies at the heart of much of the controversy surrounding potential human radiation effects. In the end, such extrapolations from high doses to low doses are based on theoretical biophysical considerations convenience of application but not on hard human data.

This task specifically focuses the pictures of the world developed in Tasks #2 and #3 onto general areas associated with the role of nuclear science and technology on future world environments. Students will address issues in regard to how nuclear science and technology will impact future decision making throughout the world.

Your task assignment is to speculate about the impact research in nuclear medicine will have on the decision making process in the nuclear world 20 to 50 years from now. You are expected to approach the assigned task from different geopolitical perspectives, to collect appropriate data and come up with responses that reflect interaction between these different perspectives. You are to explore broadly alternative possible futures and their implications.

You must prepare a series of researched responses to the tasks listed below, within the context of the four domains (science, economics, politics, and social/cultural). The focus of these tasks is comparing different applications of nuclear physics in the realm of medicine, business and home applications.

In developing an understanding and a vision for the future of nuclear medicine and businesses designing and selling equipment using nuclear technology, we must look at the past, current realities, and projected future as we begin to narrow our research efforts toward specific areas of concern.

1. Develop and discuss a vision in regard to the possible future world environments focusing specifically on the role of nuclear science and technology, specifically nuclear technologies and their use in medical, industrial and home applications and how they may shape future policy decisions.

2. Develop several scenarios that could globally or regionally describe world environments and justify each of your developed scenarios. You may want to consult with community members to get a well-rounded perspective on critical issues that shaped previous global change. You should consider the following areas:

- Examine the role of nuclear science and technology in medical applications
- Examine the role of nuclear science and technology in industrial and home applications
- Examine the controversial applications of nuclear science and technology in such areas as food preservation, sewage sterilization, nuclear waste disposal, etc.



Suggested Classroom Activities for Task #5

- 1.** Have the students identify uses of nuclear physics in medicine. Have students consider and discuss issues surrounding nuclear medicine in the context of the four domains (science, economics, politics, social/cultural).
 - 2.** Have students identify various industrial uses of nuclear materials and its impact on human societies. Have student discuss the differences in the needs of business and government in regard to nuclear technologies.
 - 3.** Identify nuclear weapons spinoff technologies in business and medicine and home applications. Have students discuss the viability of each technology and whether current human endeavors would finance such technology for a safer future.
 - 4.** Examine the role of diplomacy in maintaining a nuclear medicine capability. Have students break into teams, one team taking the role of a nuclear capable country intent on keeping "all nuclear technologies" an opposing view, and hold an academic dialogue with each team justifying their viewpoint.
 - 5.** Examine the issues in different geopolitical areas of the world where the need for nuclear medicine is not currently available. How might representatives make decisions toward the pursuit of these technologies. Discuss how their general population would acts/reacts to their countries pursuit of a nuclear capability. Consider emotions, facts, energy needs, the environment, economics, etc.
- 1.** Have students examine and discuss issues associated with future applications of nuclear technologies development (i.e., medical equipment, medical techniques, safety, proliferation, pollution, waste management, etc.) Hold a debate where one side makes judgements based on emotion and the other on facts.
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Task #6 – Public Attitudes and Institutional Responses to Technology in the Future with Emphasis on Nuclear Things

"It is important not only that citizens have roles in deciding how things will be done, but also that they contribute to the process of making things happen, addressing significant problems rather than delaying action indefinitely. Deciding when action is called for is sometimes the most difficult decision. Those who have faith in the democratic process believe that the public will help insure that the right decisions are made about how and when to act"

"League of Women Voters"

1993

"I know you believe you understand what you think I said, but I am not sure you realize that what you heard is not what I meant!"

Anonymous

"What lies behind us and what lies before us are tiny matters compared to what lies within us."

Ralph Waldo Emerson

The following task is designed to allow you to examine trends that lead to some increasing distrust of science and technology with an emphasis on nuclear technology areas and whether such trends might continue into the future. You are expected to approach the assigned task from different geopolitical perspectives and to come up with responses that reflect interaction between these different perspectives.

Communication is a vital aspect between those that are doing science and those that benefit or are harmed by science. It is through faulty communication that mistrust is bred. Science has become known as the subject area that is hard to understand. For whatever reason this idea has spread, the importance of communication between scientist, politicians and the general populace has grown. If we are to move into the future, we must alleviate as much mistrust as we can.

This task specifically focuses the pictures of the world developed in previous tasks onto general areas associated with the public view, attitudes and institutional responses to the role of nuclear science and technology on future world environments. You will address issues in regard to how nuclear science and technology is viewed and how these views and attitudes impact future decision making throughout the world.

Your task assignment is to speculate about the impact the public will have on future nuclear research and how the public will impact the decision making process in the nuclear world 20 to 50 years from now. You are expected to approach the assigned task from different geopolitical perspectives, to collect appropriate data and come up with responses that reflect interaction between these different perspectives. You are to explore broadly alternative possible futures and their implications.

You must prepare a series of researched responses to the tasks listed below, within the context of the four domains (science, economics, politics, and social/cultural). The focus of these tasks is comparing historical and current responses from the general public toward nuclear physics research and application of nuclear technology in the realms of power, weapons, medicine, business and home applications.

In developing an understanding and a vision for the future of nuclear research and application of nuclear technology, we must look at the past, current realities, and projected future as we begin to narrow our research efforts toward specific areas of concern.

1. Develop and discuss a vision in regard to the possible future world environments focusing specifically on public attitudes and institutional responses toward the role of nuclear science and technology and how they may shape future policy decisions. This effort would examine whether recent trends that lead to some increasing distrust of science and technology would continue in the future.

2. Develop and conduct a public survey that would emphasize nuclear technology but would also include other new technology areas. Produce a detailed report on your interpretation of the results from the survey. You may want to consult with community members to get a well-rounded perspective on critical issues that shaped previous global change. You should consider the following areas:

- Examine historical and current public perspectives that predict possible futures (i.e., Nuclear Fear by S. Weart, America the Powerless by Dr. Alan E. Waltar)
- Examine the underlying drivers affecting public perspectives on nuclear science (nuclear weapons destruction, fear of radiation, small probability but large consequence accidents, proliferation of nuclear weapons, terrorism, etc.)
- Examine the role that national and international media plays in the development of public attitude and understanding



Suggested Classroom Activities for Task #6

1. Have the students identify areas of concern from the public's point of view regarding nuclear waste disposal/transportation/storage. Create a pro/con/compromise chart addressing the issues identified. Assign students a role based on the chart (pro/con/compromise) and hold a town-hall meeting debating an issue. Select an issue from below or create your own:

- local nuclear power plant - storage of nuclear rods
- transportation of spent nuclear rods to disposal site through your community
- planned opening of nuclear storage site near your community
- maintenance of the nation's nuclear weapon inventory
- dismantling of nuclear weapons at site outside of your community
- small discharge of radioactive tritium from research facility 50 miles downwind from your community
- obsolete nuclear medicine equipment at your local hospital
- planned tritium production facility to be added to a research facility near your community
- etc...

Remember to conduct your research and discussions in the context of the four domains (science, economics, politics, social/cultural)

2. Have students discuss the differences in the approaches taken by the government and by nuclear activist groups when informing the general populace on an identified issue.

3. Have students read America the Powerless by Dr. Alan E. Waltar. Hold a class debate with 1/3 the class taking the perspective advocated by Dr. Waltar, 1/3 advocating the perspective of an activist group and 1/3 taking a neutral stance.

